



Aeronautics

New Wing Design Exponentially Increases Total Aircraft Efficiency

Technology also applies to propulsion systems and turbines

Innovators at NASA's Armstrong Flight Research Center are experimenting with a new wing design that removes adverse yaw and dramatically increases aircraft efficiency by reducing drag. Known as the PRANDTL-D wing, this design addresses integrated bending moments and lift to achieve a 12 percent drag reduction. The approach to handling adverse yaw employs fine wing adjustments rather than an aircraft's vertical tail. The technology has the potential to significantly increase total aircraft efficiency by optimizing overall aircraft configuration through the reduction in size or removal of the vertical tail as well as the reduction of structural weight.

BENEFITS

- ➔ **Highly efficient:** Reduces adverse yaw when correcting for roll
- ➔ **Economical:** Improves fuel efficiency by allowing aircraft to fly faster
- ➔ **Safer:** Reduces adverse yaw when correcting for roll
- ➔ **Simpler:** Requires no vertical stabilizers, easing production

APPLICATIONS

- ➔ Mid-sized commercial aircraft
- ➔ Drones, unmanned aerial vehicles (UAVs)
- ➔ Turbines
- ➔ Energy delivery systems

technology solution



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THE TECHNOLOGY

Adverse yaw, present in current aircraft design, is the horizontal movement around a vertical axis of an aircraft in the direction opposite a turn. As an aircraft banks, differential drag and the slight change in velocity of the left and right wings contribute to aircraft inefficiency. Proverse yaw—yawing in the same direction as a turn—would optimize aircraft performance. Initial results from flight experiments at Armstrong demonstrated that this wing design unequivocally established proverse yaw.

How It Works

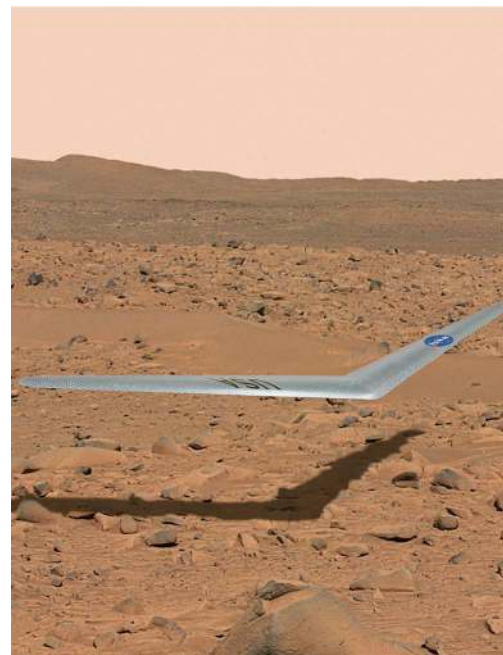
The Armstrong team (supported by a large contingent of NASA Aeronautics Academy interns) built upon the 1912 research of the German engineer Ludwig Prandtl to design and validate a scale model of a non-elliptical wing that reduces drag and increases efficiency.

The key to the innovation is reducing the drag of the wing through use of an alternative bell-shaped spanload, as opposed to the conventional elliptical spanload. To achieve the bell spanload, designers used a sharply tapered wing, with 12 percent less wing area than the comparable elliptical spanload wing. The new wing has 22 percent more span and 11 percent less area, resulting in an immediate 12 percent drag reduction. Furthermore, using twist to achieve the bell spanload produces induced thrust at the wing tips, and this forward thrust increases when lift is increased at the wingtips for roll control. The result is that the aircraft rolls and yaws in the same direction as a turn, eliminating the need for a vertical tail. When combined with a blended-wing body, this approach maximizes aerodynamic performance, minimizes weight, and optimizes flight control.

Why It Is Better

Conventional aircraft make use of elliptical wings to minimize drag. However, achieving aircraft stability and control in conventional elliptical wings requires a strong adverse yaw component in roll control (i.e., the aircraft will yaw the opposite direction with application of roll control). Therefore, a vertical tail or some other method of direct yaw control is required, such as split elevons for use as drag rudders. The use of elliptical wings also results in a suboptimal amount of structure to carry the wing root bending moments.

Adopting the bell-shaped spanload change results in an immediate 12 percent drag reduction. In addition, optimization of the overall aircraft configuration, as well as extension of the concept to propulsion systems, is projected to result in significant overall performance increases. Applications to wind turbines and fans are also being explored.



PRANDTL illustration on Mars

PUBLICATIONS

Patent Pending

National Aeronautics and Space Administration

Technology Transfer Office

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